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Abstract

Radical legal innovations in intellectual property protection have been introduced by the little noticed European Database Directive of March 1996. This initiative, part of the larger institutional transformations initiated in response to the economic ramifications of rapid progress in digital information technologies, poses numerous contentious issues in law and economics. These are likely to create ambiguities for business and non-profit activities in this area for years to come, and the terms on which those issues are resolved will materially affect the costs and organizational feasibility of scientific projects that are of global reach and significance. This is the case especially in fields such as geology, oceanography and climatology, which depend heavily upon the collection, management and analysis of large volumes of observational data that cannot be regenerated. More generally the conduct of open, collaborative science - along with many of the benefits that flow from it for the developed and the developing economies alike - may be seriously jeopardized by the consequences of the new database protections. This raises the spectre of a new and different "tragedy of the commons," one created by continuing the unbalanced pressure to extract greater economic rents by means of controlling access to information. "Over-fencing," which is to say, the erection of artificial cost barriers to the production of reliable public knowledge by means of reliable public knowledge, threatens the future of "the public knowledge commons" that historically has proved critically important for rapid advance in science and technology.

The paper sets out the economic case for the effectiveness of open, collaborative research, and the forces behind the recent, countervailing rush to strengthen and expand the scope of intellectual property rights protection. Focusing upon innovations in copyright law and the sui generis protection of hitherto unprotected content, it documents the genesis and analyzes the economic implications of the EC's Database Directive, and related legislative proposals (H.R. 3125, H.R. 354 and H.R. 1858) in the US. The discussion concludes by advancing a number of modest remedial proposals that are intended to promote greater efforts to arrive at satisfactory policy solutions for this aspect of "the digital dilemma."

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1. Boomerang – the Tool and the Metaphor: A Prologue

When the effects of modern digital information and communications technologies are considered from the standpoint of the global communities engaged in scientific research, ICTs can be likened in some respects to a "boomerang." The boomerang we all know in actuality is a remarkable creation of Aboriginal Australian ingenuity: a curved wooden tool devised for hunting. My allusion to it in the subtitle of this paper, therefore, is wholly metaphorical. The peculiarly interesting property of the artifact in question lies in its propensity (when properly thrown) to return to the origin point of its trajectory, should it miss the intended target. This proves quite handy, in permitting the skilled user armed with only one such projectile to make several attempts in reasonably close succession to stun small game at a distance. But the same property also means that failure to pay close attention to the path of the boomerang's flight is quite likely to bring the launcher, or those standing close by, a sharp knock on the head.

The boomerang's aerodynamic qualities in this regard make it a particularly suitable metaphor for the larger class of clever human contrivances that harbor the potential to react back, visiting injury upon those who have launched them. Even the indirect, curving nature of its return path to the launch point is apposite to the emerging situation that I wish to discuss on this occasion, as will soon become apparent. This metaphor is meant to fix your attention – along with that of other leaders from the worlds of government, industry, academic research and legal authorities concerned especially with intellectual property rights – upon a number of seemingly innocuous if not salutary developments in the legal protection of novel forms of intellectual property that may turn out to be grievously damaging to the global enterprise of science that holds such enormous potentials for improving the well-being of people all around the world.

I am referring, in particular, to the indirect repercussions in the international regime of copyright protections that have followed in the wake of the recent, spectacular advance in information technologies. Although indirect, largely unanticipated, and too little noticed in the midst of the concerns raised over the patenting of transgenic organisms and genetic material, these legal sequelae of the digital technology revolution are certainly changing and in some respects threaten to undermine parts of the institutional infrastructure that has historically supported the pursuit of reliable and useful knowledge through open collaboration in scientific research.

The particular problem on which I want to focus attention here is not simple. Yet, it is possible for me to begin by presenting its generic features in the following, reasonably simple terms. Knowledge is not an ordinary commodity, but instead has several properties that economists identify as those characterizing the general class of "public goods."[1] As is well known, competitive markets cannot be relied upon to perform well in allocating resources to the production and distribution of commodities that have those properties, because they interfere with the ability of private investors to fully appropriate the economic benefits that are created by new knowledge and information goods.

[1] The three generally recognized properties are: (1) non-rival possession, which is made possible by the "perfect expansibility" of ideas; (2) low marginal cost of reproduction and distribution which makes it more difficult to exclude others from gaining access to them; (3) substantial fixed costs of original production. See section 4, below for further discussion.

A variety of market and non-market institutional mechanisms may be deployed to address the so-called "appropriability problem," and, typically, several among these are found to be deployed simultaneously by modern states, in order to encourage the provision of public goods in the shape of scientific and technological knowledge. Some years ago, in another conference presentation to the World Bank, I referred to the three principal institutional devices as "the three P's": public *P*atronage, state *P*rocurement (or, alternatively *P*roduction), and the legal exclusive ownership of (intellectual) *P*roperty.[2] But, each of these exhibit some special deficiencies as well as some specific virtues in its effects upon resource allocation; none among them offers a perfect solution.

To obtain both rapid production and distribution of public goods in the form of scientific and technological knowledge, and to elicit the amount of investment needed in translating new knowledge into a rapid pace of economic welfare-enhancing innovation, it therefore is necessary to devise a system in which these distinct institutionalized mechanisms are kept working properly in conjunction with one another. In the interests of improving the long-term performance of the system in generating scientific advances and technological innovation, no one (among the several means available for coping with the public goods "appropriability problem") should be permitted to encroach upon the spheres in which the others function most effectively. The design of each should be re-evaluated and modified where necessary in order to accommodate, rather than undermine, the viability of complementary institutional mechanisms.

In other words, the task of science and technology policy for economic development may be seen to be that of achieving and maintaining the right balance in the deployment of the several devices. Recently, however, the opportunities and disruptive effects created by technological change itself have set in motion economic and political pressures that are tending to unbalance the innovation systems of many of the world's economies. Greater reliance is being placed on the "property" solution, by extending the domain of private ownership and strengthening the legal protection of intellectual property rights. The "un-balancing" effect which this is having within the regime of intellectual property is to be seen in the nature of the additions made to the ever-widening, and increasingly dubious range of applications found for established principles of patent, copyright and trade secrecy law; and also in the creation of quite novel *sui generis* legal protections for business investments involving information-goods, which in some cases have departed radically from established principles.

But, at the overall innovation system level, too, imbalances are appearing as a consequence of the strong and persisting policy consensus that presently favors providing subsidies for national industrial development in the form of monopoly rights to the exploitation of new knowledge. The problem is not so much intellectual property rights mechanism itself, which although imperfect, has been found to work well enough when it

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[2] See David (1993), esp. pp. 226 ff. The term *Patronage* stands here for the institutional arrangements for awarding publicly financed prizes, research grants based on the submission of competitive proposals for scientific peer review, and other subsidies to private individuals and organizations engaging in discovery and invention – in exchange for full public disclosure of their findings. "Patronage" characterizes the pursuit of open scientific inquiry and is the dominant institutional and social mode of organization associated with the conduct of academic research in the democratic societies of the West. On the connection between patronage institutions and the historical emergence of open science, see, e.g., David (1998). Patronage contrasts most immediately with *Procurement*, which is associated with governmental contracting (or direct production) arrangements, generally, and for performance of scientific research in particular.

comes to stimulating private investment in the exploitation of commercial opportunities based upon existing bodies of scientific and engineering knowledge.[3] What is more problematic for the long run, however, is that an unchecked bias towards expanding of the domain of information-goods within which private property institutions and market mechanisms flourish, is steadily encroaching upon the domain of public information. In doing so, it has tended to weaken, and may in the end seriously undermine those non-market institutions which historically have proved themselves to be especially effective in sustaining rapid growth in the scientific and technological knowledge base that is available to be exploited.

So much for this introductory, capsule sketch of the generic and necessarily rather abstract features of the increasingly worrisome situation that has emerged in the past decade, and which adversely affects the prospects for future knowledge-driven economic development. Now I must try to indicate in considerably more specific terms one particular set of issues that connect the future vitality of the global communities engaged in open science research, and the present trajectory of the evolving legal protections accorded to intellectual property rights in science and technology. In addition to being an especially fraught manifestation of the larger problem, the ways in which these two areas of concern are linked with each other, and entangled with the effects of the revolution that has taken place in digital communications technologies, in themselves make for an illuminating story. The case of the "digital technology boomerang" offers yet another illustrative exemplification of the importance of adopting a systems-analysis approach when setting policies for science, technology and economic development.

The current acceleration of the process of modifying statutory provisions for the protection of copyrights to better adapt them to the realities of the new technological milieu, has been set in motion by the astounding scientific and engineering achievements in digital computation and telecommunications. But, it should be recalled that publicly funded research groups in the international basic science communities historically have played pioneering roles in launching the digital revolution.[4] What strikes me as being particularly ironic, as well as disturbing in the present situation, is that the likely effects of the reactions that have been triggered in the intellectual property rights regime are of a kind so inimical to the health of other, long-standing practices and institutional arrangements for the exchange of information and data. Not accidentally, the latter arrangements are critically important for the continuing advancement of scientific knowledge. Consequently, the digital revolution's unexpected legal side effects may vitiate the direct economic benefits that enhanced information and communications technology (ICT) otherwise might have been expected to provide to the international research community. Will the mode of scientific inquiry that was responsible in great measure for the technological foundations of the modern information revolution thus receive a collective "knock on the head" – through the agency of their own technical creations? Yes, quite possibly, especially if we are inattentive to the path along which the digital technology boomerang appears to be moving.

[3] It is true, of course, that consumers of the innovative goods and services that are provided under these arrangements will usually bear some burden in the form of the higher prices that monopoly-holders may extract, so long as they enjoy their temporary freedom from the competition of imitators. But this already is widely acknowledged, and so does not require the same attention as the issue upon which this paper is focused.

[4] See, e.g., National Research Council (1999) for one recently documented part of this history.

Innovations that create unexpected disruptive and destructive effects of a reflexive kind, damaging to the economic, social and cultural environs of their creators, although not directly injurious to those who initiated them, certainly have figured frequently in the historical annals of science and technology. Of course a more vivid rendition of that general theme continues to flourish in literary and popular imagination, following its classic expression in Mary Shelley's tale of the inventor *Frankenstein*. If one doubts that this vision of the dangers of scientific hubris remains very much with us today, consider that at the height of the recent European hysteria over the testing and marketing of genetically modified plants, the favorite headline of Britain's tabloid press was: "FRANKENSTEIN FOODS!"

What I have in mind, however, bears scant resemblance to that hackneyed allegory of the unwitting scientist unleashing an uncontrollable monster. Rather, the tenor of the discussion I aim to stimulate by my reference to "the digital technology boomerang" is much more akin to the one initiated by Rachel Carson's *Silent Spring* in 1962. The publication of that book called attention to the indirect and complex pathways through which the products of human chemical ingenuity (then being liberally applied in eradicating insect-borne disease and enhancing agricultural productivity) were poisoning the human habitat. At the very least, the ironic theme of impending reflexive injury may prove useful in the present context, if it serves only to raise the awareness of members of the world's research communities of the threatening changes that are now taking place in their institutional environment. The particular problem I have chosen to examine on this occasion will be seen to deviate from the canonical literary form in at least one respect: this is not going to be a story in which the authors of some scientific or technological breakthrough are able to walk away comparatively unscathed from the disruption and damage that the practical fruits of their research unexpectedly have visited upon the rest of society.

2. The Digital Dilemma and the Enterprise of Open Science: An Overview of the Problem

The explosive developments that currently transform computer-mediated electronic communications most certainly will impinge in various ways upon the organization and conduct of scientific and engineering research. The emergence of new communications facilities that are available at dramatically reduced costs affects everything from new, electronic working paper and journal publications, and specialized dynamic database services, to the prospective growth of an upgraded Internet that will support enhanced information search, filtering and retrieval services, virtual laboratory environments, and remote shared access to large experimental research facilities. These tools are almost certain to alter profoundly the way that normal science research projects are organized and funded during the 21st century. But, if the opportunities of collaboration and sharing of both physical and data resources on a global scale are in the process of being greatly expanded, there also are counter-tendencies that may undermine long-established traditions of co-operation and curtail the domain of open scientific endeavor.

It is upon this second, more troubling aspect that I wish to focus, namely, the implications for the enterprise of open science of the nexus that has formed between the digital technology revolution and the process of institutional innovation that is transforming the regime of intellectual property rights in science and technology.[5] The swing of the policy

[5] On the nature and historical origins of "open science," see, e.g., Dasgupta and David (1987, 1994); David (1998).

pendulum in the US and other highly advanced economies towards more extensive reliance upon strengthened patent and copyright protection for innovations, part of which has been the portrayal of these legal provisions as crucial for eliciting private investment in invention and commercialization of new products, has received impetus from a number of distinct sources. In some measure it was a defensive reaction to the emergence during the 1980's of intensified global competition from new producers who had acquired surprising technical capabilities, especially in rapidly absorbing new production methods and applying these to imitate, adapt and eventually elaborate upon novel goods first introduced in the advanced economies.

Secondly, some added momentum was gained from undertakings on the part of fiscally straightened governments during the 1990's to cut expenditures by transferring to the private sector a range of data production and information distribution activities that formerly were publicly provided. A third factor has been the rise of venture financing for new technology-based start-up companies, and the role that the existence of a portfolio of patents came to play, as both a signal of creative scientific and engineering competence, and a useful impediment to the rapid entry of competition into the market niche targeted by the new enterprise. The same may be said in regard to some forms of copyright, although the legal protections they afford generally are thought to be weaker and potentially less valuable than those which patents can provide. But not only venture capitalists and business managers are attracted by the commercial advantages that may be secured by obtaining intellectual property rights; the more entrepreneurially inclined scientists and engineers among those engaged in university-based and public foundation sponsored research, increasingly are found seeking patents or copyrights for their discoveries and inventions. Indeed, recent changes in government policy affecting the technology licensing of activities of universities and public institutes have been encouraging this new trend.

Fourthly, behind much of the impetus to adapt inherited regimes of copyright protection for use in the new technological environment of digital coding and electronic data transmission and copying, one can discern strong economic interests seeking to contain the disruptive effects upon traditional business models in the publishing industries, as well as to facilitate the commercial exploitation of these new digital technologies.

Fifthly, and surely most significantly in recent years, in fields such as biomedicine, information technologies and telecommunication network services the rapid pace of advance of discovery and invention has heightened the drive on the part of business concerns to find more effective mechanisms of protection against the profit-destroying entry of “copy-cat competitors.” This reflects the fact that innovative commodities in those fields tend to be characterized by the combination of high fixed costs of development with very low unit costs of reproduction, rendering the position of the lead innovator especially perilous if others can simply copy and replicate their products.

Statutory modifications of the intellectual property regime are thus seen by many as essential if the new technical capabilities for electronic network distribution of digitized information are not to be crippled by an obsolescent institutional infrastructure, such as the protection of copyright that has evolved from the grants of monopoly privileges made to printers in the era of Guttenberg.[6] It is both evident and understandable that IPR innovations generally are being directed towards facilitating the continued workings of markets in the age of electronic publishing and distribution of entertainment products (music and video); and

[6] On the historical evolution of copyright protections, see, e.g., David (1994) and references therein.

towards providing incentives for more private investment in developing convenient means for consumers to access the contents of digital message streams.

It is evident that in publishing industries experimentation with new business models has been induced by the new, digital technology-based created economic conditions of negligible transmission and copying costs. Typical of the transformed business strategies has been the provision of nominally priced or freely distributed data and applications programs, coupled with the offer of related (upgraded, enhanced and more up-to-date) information goods and services on a fee-for-service basis. New computer-based methods of encryption, and copy-protection, along with digital monitoring techniques (e.g., embedded "watermarks") that can be deployed by the distributor to thwart unauthorized reproduction of digitized material, have also are being deployed; in some instances to reinforce old business models based upon copyright protection, but cases as a means of implementing a two-part pricing strategy for marketing information goods that does not depend upon the protections of copyright laws.

The phrase "the digital dilemma"[7] lately has begun to be applied in referring to the challenge posed by the need not only to accomplish the supply-side tasks of adapting the business of publishing to the digital age, but also to do so without seriously sacrificing the economic interests of the ultimate users of data and information. The newly augmented, fully digital information infrastructure – comprising computer networks, the integrated set of technologies that constitute the World Wide Web, and the distributed libraries of information in digital form – is at once a remarkably powerful medium for publishing, distributing and controlling information, and the world's largest reproduction facility. It has the potential to enormously improve access to information, and, at the same time it affords technological means of inhibiting access in ways that were never before practical.

In discussions about how a proper balance between those effects might be managed through changes in intellectual property institutions, it is well recognized that it may not be possible to steer a course that avoids winding up with one or the other of the classic policy mistakes. On the one side, there is the risk of not leaving sufficient profit incentives for commercial producers of novel information goods and services, whereas on the other side, there is the danger that society as a whole will have been burdened to an unnecessary degree by the inefficiencies in resource allocation that result from the legally sanctioned restraints placed on access to existing bodies of knowledge and information-goods. In addition, of course, there is the vexed question of how the benefits of the induced innovations are to be shared: is the societal need for more investment of the sort that will be forthcoming sufficiently great to justify giving intellectual property owners (particularly copyright-holders) the unrestricted power to charge whatever prices they wish? Should they thus be allowed to shift in their favor the distribution of whatever incremental producer and consumer surpluses have been created commercializing the innovation?

The essential nature of the "trade-offs" between opposing economic interests that currently animates these questions is not new. Indeed, it has been aired thoroughly in the long history of policy debates over the benefits and costs of creating temporary intellectual property monopolies in order to encourage investment in commercially-oriented innovation activities. Yet, those national and international debates have been much preoccupied with patent issues; and even in the past and recent discussions of "the digital dilemma," relatively little attention has been devoted to the ways in which the protection of intellectual property rights in the digital age may obstruct shared access to reliable and up-to-date information and data, and thereby seriously impede the systematic accumulation of scientific knowledge. As a

[7] See National Research Council (2000), esp. pp. 1-3.

consequence of the construction of novel and potentially legal rights in intellectual property, and the encouragement of public and quasi-public institutions in making use of these to attract private sector funding as a way of meeting the high first-costs of making digitized archives available on electronic networks, larger and larger portions of the public data "commons" are being "enclosed" and transformed into private monopolies.

This unintended consequence of the digital technology revolution actually may sap the future vitality of the global public science system. That possibility has been rendered worrisomely plausible by the direct implications and some unanticipated *sequelae* of the European Commission's Directive on the Legal Protection of Databases, which was issued in 1996. Even today, not many among those who should be concerned actually are aware of the provisions that it requires the EU member countries to implement in their national statutes. The Directive in effect established a new form of copyright in databases, one that extends to contents previously in the public domain and otherwise not copyrightable. It narrowly restricted the application of the principle of allowing exclusions for "fair use" in research, and it permitted virtually indefinite renewal of copyright protection for databases without requiring the substantial addition of new and original content.

In addition to initiating mimetic legislative proposals in the US Congress, the radical innovations introduced by the European Database Directive has posed a number of contentious issues in law and economics which are likely to create ambiguities for business and non-profit activities in this area for years to come. The ways in which these are resolved will materially affect the costs and organizational feasibility of carrying through some kinds of scientific projects that are of global reach and significance, especially those in the fields of geology, oceanography and climatology that depend heavily upon the collection, management and analysis of very large volumes of observational data.

Thus, the spectre before us is that of a new and different "tragedy of the commons." It would be the tragic destruction of the public knowledge base necessary for scientific and technological research by "over-fencing" – the erection of artificial barriers whose purpose is the extraction of economic rents.[8] Unless systematic monitoring of such incursions can be organized on a global scale, and unless countervailing measures, such as compulsory licensing provisions, can be mounted quickly both at the national and international levels, the conduct of open, collaborative science – along with many of the benefits that flow from it, for the developed and the developing economies alike – may be seriously jeopardized. Ironically, and surely it would be a wicked and avoidable historical irony, serious damage could be done to the institutions and norms of open by these unintended repercussions of the very same digital technologies to whose development public sector science itself contributed so crucially, and from which it otherwise might derive so much reinforcement.

The following sections of this paper undertake more fully to describe and document the developments to which I have been pointing. They indicate the importance for future economic growth and human well-being of checking and where possible reversing the rush

[8] The "tragedy of the anticommons" is a phrase coined by Heller and Eisenberg (1998) to refer to the problem of excessive fragmentation of patent rights in the technological knowledge base for commercially-oriented innovation activities, which may inhibit private investment by imposing heavy transactions costs in assembling the necessary licensing rights. Use of this label is eschewed because the focus of concern here is on a different problem, involving obstacles to academic researchers' rapid access to informational inputs required for their work.

towards stronger and more comprehensive intellectual property protections; and especially preventing that movement from further unbalancing national and transnational systems of science-based innovation. They examine more closely the complex of historical circumstances that have given rise to the present mixture of opportunity and danger that posed the "digital dilemma" facing policy-makers today. They analyze the genesis and implications of the EC's Directive on database protection, as an illustrative exemplification of what has gone wrong, and could continue to go wrong. The paper concludes by asking "What can be done?" and makes a number of modest remedial proposals, by way of encouraging greater efforts to arrive at satisfactory policy answers.

3. The Symbiotic, Reciprocal Relationships Linking Natural Science Research and ICTs

To fully savor the irony of the "digital boomerang", one must start with an appreciation of the basic research communities' long history of contributing new materials, tools and methods to the world of commercial production and distribution. Of course, technological advances in the industrial production of equipment and instruments, as well as in materials such as chemical reagents, reciprocally have been augmenting the power of experimental and observations research methods and re-directing the aims of scientific inquiry at an ever-accelerating pace since the seventeenth century. Few facets of this reciprocal relationship have had more profound impact than the evolving nexus between scientific research and information and communication technologies (ICTs). Beginning with systematic inquiry into semiconductor effects, leading to the invention of the transistor at Bell Laboratories in the 1950's, and continuing with developments in the field of solid state physics, lasers and fibre optics, injections of new scientific knowledge have provided a basis for the continuing accumulation of innovations and improvements in computers and computer-mediated telecommunications.

In addition, research programs in the fundamental and applied natural sciences have historically been important drivers of ICT advance, due to the performance requirements and novelty of scientific instrumentation and the heavy computational demands in some fields of scientific investigation, such as nuclear and high energy particle physics; and, more recently, in geophysics and the observational environmental sciences. Thus, "pressures" for improvements in data processing, and information storage, transmission and retrieval capabilities, which were generated on the research frontier in decades past, have induced significant information technology innovations whose spreading application has begun to have major societal and economic consequences. It was the needs of the geographically dispersed university-based researchers engaged in the Advanced Research Program to enable digital information exchanges across heterogeneous computer platforms that issued in the design of the simple, robust (TPC/IP) data communication protocols that were used first in the ARPAnet, then in NSFnet, and eventually made possible the explosive extension of the Internet. Similarly well known are the proximate basic science contexts that fostered the creation of the World Wide Web browser technology, from the efforts of Timothy Berners-Lee to provide a digital information linkage system that would support the needs of the global community of particle physicists working on the experimental facilities constructed at CERN.[9]

[9] See, for recent accessible accounts of the Internet's history, e.g., Abbate (1999) and Naughton (1999); on the development of the World Wide Web, Berners-Lee (1999), CERN (1997).

Information and communication technology, in turn, has been reshaping the conduct of scientific activities and significantly augmenting the task productivity of research workers in many fields.[10] It has done so by providing, in the shape of the computer, an ever more powerful general purpose scientific instrument – available for simulation, the generation of experimental variety and optimization in more realistic models of real world systems, as well as for controlling, recording and analyzing experimental and observational data. The use of ICTs for facilitating scientific exchange includes the formation of linkages between research communities and among individual researchers on a global basis. Data communication methods are increasingly valuable in providing access to experimental data, much of which is extraordinarily expensive to gather (e.g. space missions) or represent a unique resource for the study of dynamic systems (e.g. satellite and oceanic observation). In recent years, the potential of data communication has been extended beyond the aerospace and oceanic applications to the remote control or remote management of scientific instruments for experimental investigation, involving some of the most complex trials of "tel-working" (involving real time distant collaboration) that have been undertaken.

The growing use of ICTs in scientific investigation is producing a rapid accumulation of stocks of observational data, mathematical models of real world systems, simulation and other data generated from computation, descriptive and explanatory information about scientific subjects, and so forth. For convenience all of these types of data and information can be referred to as "scientific data" or "information."[11] The accumulation of this scientific information in ways that facilitate its use by and distribution to other researchers is an important, nay, a crucial means of realizing the potentialities for closer co-ordination and integration of research, and to support further specialization and augmentation of capabilities within the international science community.

It is not yet clear whether the great advances in computer mediated communications have been the driving force behind the rising frequency of international scientific collaboration that has become more pronounced since the late 1980's, or whether these simply facilitated a trend impelled by other developments, including the ending of the Cold War.[12] But it is evident that open and easy exchanges of published information and underlying data among the participating researchers remain essential to the success of this particular form of remote co-operative work, as well as for rapid dissemination and evaluation of research findings. Increasingly, research in the sciences (including the social sciences) has come to be organized through networks, and conducted by teams whose members are drawn from geographically separated institutions and research units. They utilize data from multiple sources, varying in character and size from the results of a single observational experiment presented in a table of a journal article, to the enormous collections of observations compiled from the readout of meteorological remote-sensing instruments, geographic information systems, particle accelerators, and the systematic aggregations of

[10] See, Moulton, Young and Eberhardt (1990) for an early and unusually revealing attempt at quantitative assessment.

[11] While some authoritative discussions of issues affecting the exchange of scientific data (e.g., National Research Council 1997) have been limited to considering access only to data generated and used in the "natural sciences," the same questions arise in the social sciences.

[12] Worldwide, the proportion of publications in (selected) scientific journals covering mathematics, physics, chemistry and biology that had international collaborators increased from 6 percent to 8 percent between 1981 and 1986, jumped to 11 percent by 1991 and reached 15 percent in 1995. See European Commission (1999), p. 40: Table 2; Walsh and Bayma (1996).

research findings that form specialized databases of chemical, genomic, medical, or epidemiological information. Such data sets may in turn be recombined and merged with new material to create new databases, the analysis of whose contents may yield novel scientific findings.

Thus, for open science research communities, databases are *dynamic* tools, not merely static sources to be passively consulted; they are formed and kept effective through an interactive process of examination, error-correction, updating, and incremental elaboration that engages the critical expertise of many individuals in the communities of researchers who co-operate in developing, certifying and maintaining these research instruments. Thus, in many contexts the value of the information to users is enhanced by the very fact that its use has been, and will continue to be shared with other researchers. Of course, that does not imply that information in the form of scientific databases must be made freely available to individual researchers and teams; government research grants, and the budgets of academic institutions today commit significant sums for the purchase of commercially produced databases. But, what it may mean is that the quality of specialized database services provided, and the commitment to the maintenance of the resource's availability that is likely to be required and expected by a community of expert researchers, cannot profitably be guaranteed by commercial database producers. Furthermore, whether scientific databases are produced by business firms or by co-operating researchers, it is important that the conditions imposed upon the users remain sufficiently convenient and flexible to support the open and rapid exchange of information: the effectiveness of these research instruments needs to be protected from being impaired by proprietary protection schemes that render use, reuse and recombination of the contents technically awkward and economically burdensome.

Despite the enormous potential of ICTs for facilitating and enhancing collaborative scientific investigations, one must recognize the enormous differences in the actual use made of these technologies that presently exists among the variety of research disciplines and national scientific communities. The disparities that persist in the availability and employment of ICTs among the world's scientists and engineers are not unlike the pronounced inequality we observe in the general material conditions under which researchers, along with other members of the globe's population live and work; and, indeed, some among those disparities arise from inter-connected causes. The broad geographical distribution of modern scientific and technological research across the globe is strongly congruent with the spatial pattern of high-productivity economic activities and high level of wealth per person. At the beginning of the 1990's over four-fifths of all qualified scientists and engineers (some four million plus, in number) were to be found in the "industrial" countries (including Australia, New Zealand and South Korea within that category); and fully two-thirds of the total were concentrated in North America, Western Europe, Eastern Europe and the western republics of the USSR. India and China together held approximately another 15 percent of the total, leaving only about 5 percent of the world's scientific and engineering workforce distributed among all the rest of "developing" (and "non-developing") economies.[13] The distribution of R&D expenditures, of course, is even more strongly skewed in favor of the advanced, industrial nations.

A survey by Annerstedt (1994), based on a variety of quantitative and qualitative indicators of institutionalized scientific research capabilities among the LDCs found 55

[13] See Annerstedt (1994), Table 3; and pp. 115ff , for the following discussion of the varied capabilities for participation in international scientific research found among the LDCs.

countries, mostly the African nations, still lacking any significant "indigenous science and technology base" at the beginning of the 1990's. The essential elements of a domestic science and technology base were judged to be present in another group, comprising 40 or so countries (Algeria, Ghana, Indonesia, Iraq, Malaysia, Paraguay and Sri Lanka, among them). But, even though countries in this category were found to have a potential to activate a higher proportion of qualified personnel in commercially oriented R&D, the absolute numbers of scientists and engineers effectively engaged with agricultural and industrial production enterprises were still very low. Thus, only about 40 among the 130 or so LDC's covered by the survey were deemed to possess a "solid" indigenous science and technology base, providing a potential for endogenous technological innovation and the ability to sustain some significant degree of collaboration in international scientific projects.

Effective contribution to the work of the global science communities by researchers situated in this latter group of (truly) "developing" economies (which includes the Asian NICs, and some Latin American countries, such as Argentina, Brazil, Mexico and Venezuela) is not guaranteed, however. It remains crucially dependent upon their having access to libraries of international working papers and archival publications, current databases, as well as to high-speed telecommunication links with distant collaborators and expensive external research facilities. Timely access of this kind is far from ubiquitously available, and lacking the means to assure such "connectivity," even the most highly trained researchers experience marginalization, rapid obsolescence of their expertise, and frustration in their chosen lines of scientific investigation, upon returning to their native countries – as many nevertheless continue to do for reasons both personal and patriotic.[14]

Of course, there are issues here of equity, and of the entitlement of people from many societies and cultures to participate in advancing knowledge – especially when that is not only likely to transform the human condition generally, but may specifically impinge upon their lives and those of their children. But, quite apart from these matters, one should recognize that the highly unequal material endowments of the world's research scientists would affect the future conduct of research on questions of global concern. Many of the scientific challenges of the coming century concern our understanding of the global environment and ecosystems. The disparities between the rich and poor regions of the world in their scientific resources and capabilities for participation in global research networks hinder our collective ability to gather, integrate and analyze observational data from numerous, spatially distributed locations. Ease of access to shared network resources, including digital archives, dictionaries, and dynamic databases, as well as to the use of observational and computational facilities, is an essential part of the infrastructure enabling such transnational collaborative programs of research. The technical conditions for providing such access at greatly reduced costs have been created, and will continue to improve, but other, less propitious developments may turn out to vitiate the benefits that such achievements seemed to promise the world's open science research communities.

4. Patronage and Property in the Production of Knowledge: A Problem of Regime Balance

[14] See, e.g., Gaillard (1994) for an interesting although pessimistic appraisal of their situation, based in good part upon analysis of survey responses from 489 LDC-resident scientist researchers, mostly in the agricultural and biological sciences, who between 1974 and 1984 had received grants from the International Foundation for Science (a non-governmental multilaterally funded organization that provides support to young scientists in and from developing countries).

The impending "tragedy of the public knowledge commons," which seems to be a predictable outcome of the unopposed forces that are driving expansion of the domain IPR and privatization of knowledge, differs diametrically from the form of "tragedy" famously recounted in the well-known work by Garett Hardin (1968). The latter was a highly evocative essay that is still cited frequently in support of the view that un-priced natural resources will be destroyed by unregulated access and exploitation. The difference lies in the character of the resources. The ideas and data that form the public information commons are not like pasturelands that may be reduced to unproductive desert by over-grazing, or schools of fish that may be harvested to the point of extinction. Knowledge and information may be concurrently utilized by many without diminishing their availability to any of the users, and they will not become "depleted" through intensive use.

This hardly is a modern insight, for the point was made almost two hundred years ago with precision and elegance in a letter penned to a Baltimore inventor by Thomas Jefferson in 1813: "He who receives an idea from me, receives instruction himself without lessening mine; as he who lights his taper at mine, receives light without darkening me." For Jefferson, this was a consequence of nature having "peculiarly and benevolently" arranged that "ideas should freely spread from one to another over the globe, for the moral and mutual instruction of man...when she designed them, like fire, expansible over all space, without lessening their density at any point, and like the air in which we breathe, move, and have our physical being, incapable of confinement or exclusive appropriation."[15]

Modern economics identifies this property of information (infinite expansibility) as one of the two characteristics defining that special category of commodities known as "pure public goods," the other being the costliness of excluding others from possession of an idea once it has been disclosed. More is at stake in the present context than a definition: the economic significance of the public goods nature of ideas and data is that the operation of competitive markets cannot be relied upon to yield price signals that lead to socially efficient outcomes with respect to the production and distribution of such commodities. From this condition flows the logic of public patronage for fundamental, exploratory research, the outcomes of which constitute vital informational "inputs" that guide and enhance the expected rate of economic returns from investment in commercial applications-oriented R&D. Adhering to the analytical economics perspective that what is being protected by patents and copyrights is the exclusive right to the commercial exploitation of *information*, proves especially useful when one comes to consider the implications for scientific research activities of statutory obstacles to information access that have been created, and may yet be given force by the movement to strengthen and extend protection for intellectual property.

There is much to be said from the viewpoint of both legal theory and economic analysis for interpreting patent and copyright institutions as remarkably ingenious social contrivances, whereby protection of the discoverer's or inventor's exclusive right to commercially exploit new knowledge is exchanged for the disclosure of information that creates a public good; and, moreover, a public good that may be drawn upon to produce additional discoveries and inventions.[16] Nevertheless, it ought not to be supposed that the

[15] David (1993) may be consulted for references, and further discussions of these passages in Jefferson's writings.

[16] For the legal and economic interpretations, respectively, see, e.g., Eisenberg (1989), and Dasgupta and David (1987, 1994), David (1994).

actual provisions of the laws affecting intellectual property rights fully honor this social bargain. True, no patent is valid that does not describe the invention in "clear, precise, and exact terms," thereby disclosing sufficient information to enable second-comers to practice the invention without "undue experimentation." American patent law is unusual in going farther than this, in requiring the patent applicants to disclose the best mode in which they contemplate implementing their invention. But, in practice these provisions often prove insufficient to overcome the effects of the economic incentives that patentees usually have to withhold some pertinent information, either for their private use or as a basis to extract additional rents for the transfer of know-how that is complementary to that disclosed by the patent.

Delays in the release of information add to the academic research community's concerns over the way that the workings of the patent system restrict access to new scientific and technological findings. US patent law follows the principle that priority in invention, rather than being first to file a patent application is what matters; it therefore allows applicants a one-year grace period after publication. But most foreign systems award patents on a "first to file" basis, which means that even American researchers are induced – by their own or their supporting organization's commercial goals – to delay publication of their findings and inventions until they have prepared patent applications to secure rights in other countries. During the two decades following the passage of the 1980 Bayh-Dole Act, which authorized universities in the US to seek patents on innovations arising from federally funded research projects, there has been more-or-less continuous modification of institutional rules in the direction of lengthening the permissible duration of delays placed on the publication of research findings for purposes of allowing the filing of patent applications.[17]

From the standpoint of academic researchers the greatest deficiency of the statutory disclosure requirements imposed by patent laws is simply that little scientific or technical data may be divulged in meeting this stipulation, so that the patent itself is of only limited interest and serves mainly as a notice that the patentees may be willing to supply more useful information, for some fee. Moreover, researchers' ability to make use of such information as the patent does divulge is by no means assured until the end of its life; the patent not only excludes others from selling the invention, but also prohibits them from making and using it. That the use of an invention for purposes of research, and hence in generating further discoveries and innovations, ought not be proscribed has long been recognized by patent case law in the U.S: researchers have been allowed to defend themselves from infringement suits on grounds of "experimental use" – so long as the infringer is able to show that no commercial benefit was derived thereby.[18]

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[17] The effects of the Bayh-Dole legislation (USC §§200-211: 291-307) on university patenting activity are reviewed by Mowery and Nelson (1998); Cohen, Florida and Goe (1996) report findings from a survey of US university-industry research centers on the distribution of permitted restraints on publication to allow for the filing of patent applications, and the significance of these delays and other restrictions is discussed by David (1995).

[18] Dam (1999: pp. 7-8) points out that because the case law has tended to reject the "experimental use" defense against infringement suits whenever the researcher might profit, this exception to patent protection is less likely to prove beneficial for academic researchers in fields like biomedical sciences, where even publicly-funded "basic" research may yield short-term economic payoffs. Given the case law precedents in the US, the drive on the part of university administrators to exploit patent rights under the provisions of the 1980 Bahy-Dole Act may thus be seen as contributing indirectly as well as directly to creating more formidable barriers to the ability of academic researchers to rapidly access new research tools and results.

The same situation does not arise with conventional copyright protection, since what is being protected is the published form in which ideas have been expressed; only that which is fully disclosed can qualify the author for legal protection against infringers. Inasmuch as it is difficult, if not impossible to establish that unauthorized copies were made of a text which had not been made public in some way, authors seeking legal protection for their work have every incentive to hasten its disclosure. Moreover, in recognition of the cultural and scientific benefits of exegetical and critical writings, and further research based upon published information and data – not to mention the interests of authors in having such usage made on the basis of accurate representations of their work – statutory exceptions traditionally are provided to permit "fair use" infringements of copyrighted material. Largely for these reasons, this form of intellectual property protection historically has not raised serious objections on the grounds of impeding rapid access to new scientific or technological data and information.

But, more recently, the extension of copyright to software has permitted a breach of the disclosure principle that parallels the one already noted in regard to patents: under American copyright law (in order to qualify to pursue infringers for damages) it is sufficient to register only some sample extracts of a computer program's "text," rather than the entire body of code. Moreover, there is no requirement whatsoever to disclose the underlying "source code"; copyright protection can be obtained on the basis of a disclosure of just the machine language instructions, which, even were they to be divulged in their entirety would be difficult and costly to interpret and re-utilize without access to the source code. While this practice surely can be seen to violate the principle that no burden of "undue experimentation" should be placed upon second comers, the latter requirement is one that holds only in the case of patent law. It never was contemplated that one might be able to register a text for full copyright protection without practically disclosing its contents to interested readers.

A further, more generally disconcerting set of developments may prove quite destructive to the effectiveness of traditional safeguards against "fair use" exemptions for research (and educational) purposes – even where such provisions continue to be made. This threat has emerged only recently in the form of digital technologies that limit "on line" copying of electronic information. Advanced encryption systems now underpin many computing and communications security services, and permit a wide variety of security objectives to be achieved by establishing discretionary control over access to encrypted data, along with assurance for both users and service provider of message authentication and data integrity, as well as privacy and confidentiality goals. There are other techniques for marking and monitoring the use of distributed digital information, such as "water marking," which attaches a signal to digital data that can be detected or extracted later to make documentable assertions about its provenance, authenticity, or ownership; "fingerprinting" embeds a mark in each copy that uniquely identifies the authorized recipient. "Self help" or "copyright management" systems that make use of encryption or prevent unauthorized copying of "cleartext" allow copyright holders to enforce their legal claim to capture economic value from users of the protected material, and, moreover enable selective access to elements of content that makes it more feasible for the vendor to engage in price discrimination. Marking and monitoring techniques, in contrast, do not allow direct enforcement of copyrights, but can be used to deter unauthorized copying and distribution of information by facilitating tracking of errant data to the original recipients who were responsible for its improper use.

These advances in digital technology have a direct economic effect that is efficiency enhancing, insofar as they reduce the costs of enforcing a statutory property right and thereby

securing whatever societal benefits copyright legislation is designed to promote. Yet, in the currently prevailing enthusiasm for stronger intellectual property protection, the American drafters of the 1998 Digital Millennium Copyright Act included a provision that prohibits the circumvention of "any technological measure that effectively controls access" to a copyrighted work, and outlawed the manufacture, importation or public distribution of any technology primarily produced for the purpose of such circumvention.[19] The problem posed by this statutory reinforcement for applications of novel self-help technologies is simply that it may render impossible the exercise "fair use" of copyrighted material by researchers and educators, leaving the provision of information access for such purposes as a matter for the discretion of copyright holders.

This, however, is not the only serious assault upon the traditional means of permitting publicly supported open science communities to pursue their work untrammeled by the protections afforded to copyright owners. As attractive as the prospect of more powerful "self help" technologies may appear to be in curtailing "digital piracy," such remedies would create a threat to the achievement of a reasonably regime for the allocation of scientific and technological information goods while providing protection for private investments in information goods. One way in which it is feasible to approximate the efficient workings of a system of discriminatory pricing for data and information is to allow educators, scholars and researchers to invoke "fair use" exemptions from the requirements for licensing material that is copyrighted or otherwise legally protected by statute. In effect, this approach would set differentially lower prices for the use of information goods in producing and distributing knowledge – indeed, prices that approximate the negligibly small marginal costs of digital reproduction and transmission.

5. Making Way for the Market: Legal Rights and the Privatization of Information Goods

A variety of powerful economic forces lies behind the current world-wide movement towards transferring to the market an increasing number of functions that during the first three-quarters of the twentieth century were assumed by governments in the industrially advanced societies. The fiscal pressures to limit public patronage of institutions and activities concerned with the generation and distribution of knowledge are only one element within that broader tendency, and a relatively minor one in terms of the claim made on national economic resources for such purposes. But the ideological pressures seem powerful nonetheless, for, in the present era the language of private rights and individual action has acquired renewed potency.

Indeed, the seemingly inexorable drift towards privatization of all forms of information by extension of copyright-like protections across a widening field of application, and the strengthening of the ownership rights conveyed through new legislation and judicial opinions, has prompted legal scholars to comment upon the ambiguity of the concept of *intellectual* property, the asymmetrical definition of the private (as distinguished from the public) domain, and the rhetorical power of references to individuals' "rights" – each of which have been at work in this process.[20]

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[19] See Digital Millennium Copyright Act (1998), United States Code, 17, §1201; also, Dam (1998) for discussion of the policy issues raised by self-help systems.

[20] See, particularly, the commentary of Vaver (2000), which has inspired much of the following. Note that this

The notion of "intellectual property," of course, is a purely metaphorical construct, and one that has swept into fashion only comparatively recently. During the first half of the twentieth century it was more common for patents, trademarks and copyrights to be referred to more plainly – as "industrial property." In what sense can one really deem as "intellectual creations" many of the expressive materials that today are entitled to receive legal protection under copyright laws or parallel statutes? Do office memoranda really qualify? What about the tracks made on a cloth by cats whose feet had been dipped in paint? Or, the images captured on film, or electronically by CCTV surveillance cameras? Practically any sampling of the results of reifying the idea of "intellectual property will forcibly bring to mind the observation that employing a metaphor involves making an internally contradictory assertion, by likening one thing to another when plainly the two are not at all the same.[21]

The obvious objective of giving an "intellectual" spin to such items of property is to try to induce some greater resonance with the more culturally valued and hence "protection-worthy" expressions of literary and artistic creativity. But, the main rhetorical coup is achieved by designating the whole incoherent collection "property." To speak of "property" automatically inhibits thoughts of confiscation by the State, while promoting the extension of some people's "rights" to ownership, even though that may entail the restriction or extinction of others' ability to exercise common access to the goods in question.

Property rights both delineate and convey to the holder the legally sanctioned conditions for excluding others from trespass: they do not establish for others any *positive* rights not to be thus excluded. Although the concept of a distinct sphere demarcated as the "public domain" is well recognized under conventional intellectual property laws, what it contains is not defined and legal "rights" to its use are not delineated; "property" is what is defined by the law, and the public domain holds the residuum. Thus, the exemptions permitted for "fair use" of copyrighted material (under US copyright law and the Berne Convention) do not convey to researchers, educators or literary commentators any positive rights to reproduce expressive material without license from the copyright holder. Instead, they offer simply a legitimate ground for *defence* against suits brought for copyright infringement; the rights to exclude supervene in such cases, however, so that courts generally will grant injunctive relief to the plaintiff – stopping the publication and withdrawing materials that are alleged to have infringed her exclusive copyright. As "fair use" is not then a legally established "right," there is nothing in the law that reciprocally secures reasonable conditions of "fair use" access to legally protected texts and data for a purpose such as research or evaluation.

There is thus a general asymmetry in both law and political rhetoric that has favored the broadening of private rights and the curtailment of the sphere of common entitlements in regard to conventional, physical assets; and presently it is operating no less powerfully to encourage the privatizing of the world's scientific and technological knowledge base. Part of

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discussion refers to legal "property rights," whereas there is another conceptualization of "rights" that enables economists to speak of *de facto*, and even illegal "property rights." The latter, however, seems more closely allied to notions of the "capabilities" and "powers" of economic agents, rather than to the ideas of justice and equity. Barzel (1989) has elaborated an interesting transactions cost analysis approach to the economics of property rights defined in that more comprehensive way. The distinction just made will be seen to be germane to discussions of "anti-piracy" measures and the utilization of "self-help" technologies (e.g., encryption) for private enforcement of legal ownership rights in intellectual property.

[21] On metaphors, metanemes and their rhetorical and epistemological functions, see Johansson (1993).

this power derives from the irreversibility of changes, which cumulatively imparts unidirectionality to the process. Removing or restricting the exercise of rights that already have been granted legal recognition is politically very difficult, far more so than abrogating customary patterns of usage. Consequently, a ratchet-like mechanism comes into play in the course of virtually all efforts to codify and harmonize systems of rights. In international and interregional negotiations concerned with IPR harmonization, the general level of protections invariably are harmonized *upwards* for some of the parties rather than downwards, because it is politically hazardous for any but the most autocratic government to be perceived by its citizens as having acquiesced for whatever purpose in the surrender of "rights" that they already were enjoying.

An obvious impetus behind recent as well as historical innovations in public policy and institutional legal and regulatory regimes has been the drive to create conditions that would promote, or at a minimum facilitate the introduction of market mechanisms where these previously had little scope for operation. Increasingly, an objective of government-led initiatives is to actively foster the entry of profit-seeking enterprises into the production and distribution of goods and services that previously were not "priced," and instead were for public provision through a variety of non-market arrangements. Outwardly at least, there seem no compelling economic or political reasons why these invigorated forces favoring further commodification in the domains of information and "knowledge," should have emerged at the very same moment in history as the array of spectacular ICT advances that are rendering data and information more abundant, and cheaper to process and distribute than ever before. Indeed, the coincidence of those two sets of developments might be seen to have been simply an "accident of history": the chance conjuncture of the inter-networking phase of the digital revolution and the ending of the great power conflict of the Cold War, initiating the global ascendancy of market capitalism, and a widely felt need for fiscal retrenchment on the part of the governments of the leading industrial nations.

That is a confluence of circumstances which, although possibly unrelated in their origins and fortuitous in their timing, nevertheless are likely to have enduring consequences that will come to be seen as freighted with historical irony. In contrast with the pre-existing information distribution regime, the new reproduction technologies – and the opportunities for by-pass in data transport that digitization of text, images, and sound that they have rendered economically feasible – removed much of the prospect of being about to recoup the fixed costs of the infrastructure by selling the (common carrier) service of transmitting "bits." Integration into the provision of value-added services, and protection of the profits of those services by ownership of copyrightable and non-copyable "content" thus became the logic of the emerging business regime based upon an enhanced digital information infrastructure. The alternative solution, of having the infrastructure provided as a public utility funded from general revenues, or a mixture of user charges and tax-financed construction subsidies, seems to run against "the spirit of the times" and so simply has not received any serious consideration in public policy circles.

In my view, this is an accident of historical timing: the conjuncture of the ICT revolution with the 1980s fiscal stringency, and the early 1990's reaffirmation of the ideology of market capitalism that followed the collapse of Soviet-style socialism. It is hard, indeed, to imagine that earlier in the twentieth century the recommendation to privatize a major new form of communications infrastructure would have gained such instant approval as that which was expressed following the US government's decision in the early 1990's to open the Internet for further development by the private sector under a regime of minimal regulation.

Yet today, claims made on behalf of the academic research community for the protection of an open space, a "knowledge commons," are likely to be regarded as inimical not only to the ideology of the market, but as threatening the regime through which national and global information infrastructures can be enhanced – so that the full benefits of broadband digital communications and e-commerce might be enjoyed by society at large.

Such views, however misguided, are wedded to immediate private economic interests and therefore constitute part of the political reality that must be recognized, especially if successful efforts are to be mounted to check the further commercialization of scientific data and information. Thus, part of the reality facing academic science is that there is a need to adjust the IPR regime to cope with the otherwise de-stabilizing effects of the digital revolution upon established enterprises in the publishing business; and another part is the persistence of fiscal pressures on public agencies. That, in turn, combines readily with private interests to further the transfer to the private sector the provision of data and information hitherto undertaken as a public service by state agencies.

Quite evidently the rapid advances made during the past decade in electronic and optical telecommunications, and other components of digital network technologies, are having some profoundly unsettling effects upon the industrial organization and competitive structure of conventional publishing businesses. The disruptive impacts of these technical developments upon pre-existing business interests and established institutions are a familiar feature of the ways in which technological innovation, in the form of new processes and products, drives economic growth. Joseph Schumpeter (1913) described it as "creative destruction" – much to the shock of the academic economics establishment in the Vienna of his early career. Not surprisingly, then, some "IPR reform" initiatives have essentially been defensive responses to the disruption of the industrial status quo ante, seeking to protect existing streams of economic rent from new sources of competition; whereas other efforts have aimed to adapt the institutional and legal frameworks in ways that would create profitable applications of new technologies for competitive purposes.

A goodly part of the current ferment within legal, business and government policy circles that has been created by effort to recast and extend national laws and international conventions governing the protection of intellectual property therefore may be seen as part and parcel of the defensive manoeuvring by firms with sunk costs in obsolescent technologies who have found themselves caught in the gale of creative destruction that has been unleashed by the digital revolution. It should be recognized, however, that more systemic opportunity-seeking motives also are at work. There are respects in which the newly arising possibilities of exploiting these enhanced technological capabilities for commercial ends are directly imparting momentum to drive toward privatization of what was formerly treated as the natural domain of public knowledge. These underlying causal connections are particularly interesting, and worthy of closer examination, if only to establish that they are likely to reassert themselves and thus to resist piecemeal and sporadic efforts to hold back further incursions upon the "public knowledge commons" in science and technology.

These developments just reviewed hardly are the only institutional *sequelae* of the technologically driven alteration of costs affecting the reproduction and transmission of text, images (and voice) communications. But, the restructuring of the legal regimes relating to patents and copyrights, and the implications those induced innovations are likely to effect on the organization and conduct of scientific research and publishing. Indeed, they seem bound to figure among the more prominent unexpected consequences of the very same digital infrastructure technologies that were created by publicly sponsored scientists and engineers. Unfortunately, at least some of these repercussions now appear to be detrimental to the long-term vitality of the practice of "open" science in the world's academic research communities. Such an untoward effect will not follow from the technology itself. It comes, instead, from the lack of appropriate concern for maintaining a healthy balance between the domain of publicly supported knowledge production and exchanges, and the sphere in which flourish private, proprietary R&D and profitable businesses based upon information goods.

Too much should not be made of the separation between the spheres in which information-goods are freely shared, and that in which access to them is tightly controlled by private profit-seeking agents. At least, it is important to notice that there is a region in which the two can overlap. Indeed, business publishers actually may find it possible to enhance their profits by permitting and even facilitating free sharing of information goods among *socially connected* producer- and consumer-groups – that is to say, among bounded entities (such as families, social clubs, and work-groups) in which membership is limited by conditions other than payment of fees, and within which there is considerably less heterogeneity of demands for the goods in question than that which exists in the population at large. Allowing free sharing in this sphere, in effect, permits self-aggregation of potential customers into collectivities whose joint "willingness to pay" will significantly excess the sum of the constituent members' willingness to pay on for the good or service in question. [22] In the context of the present discussion, therefore, it is especially appropriate to point out that academic scientific research *networks* are in a sense paradigmatic of the self-selected producer groupings whose information goods requirements might be more profitably met by publisher/vendors who permitted, or actually facilitated free (intra-group) sharing.[23] Viewed from this perspective, the current rush to tighten the copyright regime and encourage strict enforcement of "anti-piracy" provisions of all kinds, may at some date in the not-so-distant future come to be perceived as having been a serious mistake, not only because its consequences were injurious to the conduct of open science, but because they were antithetical to the development and exploitation of new and more profitable business opportunities.

One source of difficulty in preserving such balance is quite immediately apparent. An attractive short-run strategy of business development entails utilizing enhanced information processing and telecommunications in conjunction with the assertion of private property rights over the mass of publicly provided data and information products. Rather than having to produce wholly new content for distribution via the new and more effective technical facilities, an obvious first line of enterprise is to make use of what comes freely and most readily to hand. Ever since the introduction of printing with moveable type, the history of new publication and broadcast media has shown how automatic it is for entrepreneurs to seek first to draw upon content that was already available in the public domain. Hence, one can expect that this approach will continue to be tried, exploiting larger and larger portions of the body of codified scientific knowledge and observational data that has been built up under public patronage and maintained as a common, readily accessible research resource. Sometimes the commercialization of public databases makes good economic sense: because private firms may have technical or marketing capabilities that would add value for a variety of end users of publicly generated data, whereas existing government agencies or NGOs lack that competence.

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[22] On the conditions under which publishers' profits are raised by permitting free sharing of copyrighted material, see Bakos, Brynjolfsson and Lichtman (1999). The authors develop an important qualification of the widely asserted claim that digitally assisted, low marginal cost reproduction encourages "piracy" (unlicensed copying and redistribution) that must be injurious to copyright holders, and therefore warrants introduction of stronger protections against all unauthorized copying. See, e.g., Liebowitz (1985), Besen (1986) and Besen and Kirby (1989), for earlier contributions in this vein.

[23] Moreover, in "the knowledge society" – where collaborative generation of new ideas and practices is expected to characterized a larger and large segment of business activity, the scientific research network, conceived of as a form of "competence based club," may become a paradigm for an economically much larger part of the market for information-goods that are research inputs.

Such was shown to be the case in regard to the distribution and packaging by commercial weather information services of data gathered by the US National Oceanic and Atmospheric Administration (NOAA).[24] But, the possibility of seriously adverse consequences elsewhere in the national research system, from ill-designed policies and programs to promote proprietary exploitation of public knowledge resources, also needs to be recognized. Consider what ensued in those circumstances from the Reagan Administration's sponsorship of the Land-Remote Sensing Commercialization Act (1984), under which the responsibility for the operations of the Landsat system of remote sensing satellites was transferred from NOAA management, and a monopoly on Landsat images was awarded in 1985 to the Earth Observation Satellite (EOSAT) Company, a joint venture of Hughes and RCA. The price of Landsat images immediately rose 10-fold, from $400 per image to $4000. This permitted EOSAT to attract profitable business from commercial customers and the federal government, although virtually none from academic and independent researchers. Indeed, the impact of the privatization of Landsat operations upon basic research being conducted by university groups around the world was quite devastating, as, they suddenly went from being "data rich" into a condition not of actual "data poverty" so much as one of data "non-entitlement."[25]

The EOSAT Co. secured its monopoly position in the market for satellite images by virtue of being given physical control over the source of (Landsat) images. Yet it is equally possible to imagine that a similarly damaging outcome for academic researchers would follow from the exercise of the market power that a commercial provider of a scientific database might gain under intellectual property protection; especially under a legal regime that granted indefinitely renewable copyright protection to the database contents, whether or not the data was otherwise copyrightable. It will be seen (from the discussion in the following section) that such is the import of the European Commission's Directive on the Legal Protection of Databases, issued on March 11 1996; and similar circumstances also might arise under the terms of at least one (H.R. 354) of the two database copyright bills presently being considered for passage by the US Congress.

6. The European Commission's Database Directive and Its Economic Implications

A new and quite unexpected direct threat to the academic research enterprise in science and engineering has emerged since the mid-1990's, as a result of the extension of *sui generis* copyright protection to databases, even to databases containing non-copyrightable material. This institutional innovation emerged first in the European Union Directive on the Legal Protection of Databases (issued March 11,1996), which directed member states to create a new broadly comprehensive type of intellectual property that was free from a number of the important and long-standing limitations and exceptions traditionally provided by copyright law, in order to safeguard access to information used in socially beneficial, knowledge-creating activities such as research and teaching. The EU Database Directive applies equally to non-electronic and electronic databases, even though, as will be seen, it

[24] See National Research Council (1997), pp. 116-124, for material underlying this and the following discussion.

[25] The introduction here of the term "non-entitlement" is a deliberate allusion to Amartya Sen's observation that people starved in the Indian famine of 1918 not because the harvest was inadequate to feed them, but because the rise in grain prices had deprived them of "entitlement" to the food that actually was available.

originated as a strategic "industrial policy" response to the commercial development of on-line (electronic) databases in America.

Further, as a device to secure international acceptance of the new approach initiated by this directive (which remains binding upon the member states of the European Union, in the sense of requiring implementation in each of their national statutes) reciprocity provisions were included. The latter in effect threatened the commercial creators of databases who were nationals of foreign states outside the EU with retaliatory infringement of copyright material in their products, unless their respective governments became signatories to a World Intellectual Property Organization (WIPO) draft convention on databases which had been framed to embody the essential provisions of the *sui generis* copyright protection established under the1996 EU Directive.[26]

The European Commission's strategy succeeded in setting in motion an Administration-initiated legislative response in the US Congress, which has now led to two competing draft statutes being actively debated. The response began in May 1996 with the introduction at the behest of the US Patent and Trademark Office of House of Representatives of a bill, H.R. 3531, short-titled the "Database Investment and Intellectual Property Antipiracy Act of 1996." This first and ill-considered rush to legislate soon encountered opposition from the US academic research community and non-commercial publishers of scientific information. But although that attempt proved unavailing, the legislative genie has been let out of the bottle, with the result that the 104th Congress presently has before it two further pieces of proposed legislation. The first of these is "The Collections of Information Antipiracy Act," H.R. 345, which was introduced in January 1999 and represents a re-incarnation of the quite pernicious approach taken in the original Administration-inspired legislative proposal in 1996. A second bill, "The Consumer and Investors Access to Information Act," H.R. 1858, was introduced in May 1999, and contains provisions protecting access to database information that are rather more responsive to the objections raised during 1997 against H.R. 3531.

This is not the occasion for a careful analysis of the proposed database legislation pending in the US. But there are several useful points to be made by looking more closely at the origins, and the economic implications for the future of scientific data production and exchange, of the institutional initiative that may be held immediately responsible for provoking this American response: the final text of the European Directive on the Legal Protection of Databases of March 11 1996.[27]

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[26] The 1996 draft was entitled: "Basic Proposal for the Substantive Provisions of the Treaty on Intellectual Property in Respect of Databases...", WIPO Doc. CRNR/DC, Geneva, August 30. It has been pointed out that in this regard, as well as in others, the EU Directive called for a departure from the principle of administering commercial laws on a "national treatment" basis, under which a country's domestic laws (whether for intellectual property production, or unfair business practices) should treat foreign nationals like one of the country's citizens. The principle of national treatment is embodied in Article 3 of the TRIPs Agreement, as well as more generally in the Paris Convention (on patents and trademark protection) and the Berne Convention (on copyright protection). Objections to this departure were recorded in the testimony of the General Counsel of the US Department of Commerce (Andrew J. Pincus), in the 106th Congress House Hearings on H.R. 1858 (1999): section F.

[27] Much of the discussion here draws upon the narrative material presented in National Research Council (1997), pp. 146-161.

The impetus for the Commission of the European Communities' proposal of a *sui generis* or *ad hoc* extension of copyright protection to databases grew out of a number of EU member countries' adoption, in varying degrees, of policies for commercializing the publication government-generated data.[28] As part of the process of formulating an overall strategy for information technologies known as the Information Market Policy Action (IMPACT) program – which was started by the Commission in the late 1980s under Commissioner Martin Bangemann – a survey was undertaken that revealed that the growth of the database business in Europe was lagging, and those in the field felt themselves to be at some disadvantage vis-à-vis American firms. The latter had got off to an earlier start and already had taken a large part of the world market, yet continued to expand relatively rapidly. Remedies were proposed, starting with the harmonization of copyright laws within a single, integrated European market, and then combined with higher levels of IPR protection tailored to the needs of potential investors in database production.

This proposal rather paralleled the arguments heard in World Bank circles during the early 1990's, regarding the positive effects on direct foreign investment of the introduction of a stronger intellectual property regime in the developing, recipient economy. But here the argument was not that intellectual property protection was needed to induce investors to be willing to disclose their technologies; rather it was that the combination of a new form of copyright monopoly and international reciprocity clauses would permit European firms to seize and hold their domestic markets, whilst being left to garner some export earnings from the sale of such data abroad for their own official government statistical products. Privatization of the government's role in collecting and distributing data was thus seen as another supporting policy to encourage entry of new database generators, as well as possibly providing income streams that would offset the shrinking availability of public funds for R&D. Here one may read the influence of the now ascendant "wealth creation" rationale that guides much European science and technology policy.

A study of comparative law revealed that at the time the Nordic countries already were experimenting with short-term, copyright-like protection of non-copyrightable compilations (known as the Nordic catalogue rule). They had taken this step with a view to curbing commercial piracy without extending full copyright production to borderline literary productions that lacked creative authorship. In 1992 the Commission embraced this idea by drafting an innovative Directive to protect such databases in electronic form. The Council of Ministers and the European Parliament adopted an amended version in July 1995, which extended the protection to databases in print media as well. It was this amended draft that issued as the final Directive on March 11 1996.

One rather remarkable aspect of these proceedings in the European Commission reflected the pre-committed policy position advanced by the 1994 report on *Europe and the global information society*, prepared for the European Council by a "High-Level Group" under the chairmanship of Commissioner Martin Bangemann.[29] Intellectual property was embraced as central to the "Vision" of the Information Society projected in the Bangemann Report (1994: Ch. 3):

[28] Such commercialization is contrary to the policy stance of the US, where the right of the federal government to copyright its data has been withheld by Congress from the early days of the Republic, and tradition has favored citizens' full and open access to non-military public sector information. The federal government does, however, file for copyrights on its publication in other national juridictions.

[29] See Vaver (1999) for the broader context of European innovation policy approaches within which recent copyright directives have been developed.

> "In this global information market place, common rules must be agreed and enforced by everyone. Europe has a vested interest in ensuring that protection of IPRs receives full attention and that a high level of protection is maintained."

This commitment sufficed in place of any inquiries as to whether recourse to *sui generis* copyright protection really was needed to stimulate European investment in database creation. How American database vendors had managed to surge so far ahead of Europe in this field, especially without the benefit of any special copyright protection, does not appear to have been a point on which the High-Level Group sought empirical enlightenment. Indeed, only the year before the draft Directive appeared, the US Supreme Court decision in *Feist v. Rural Telephone* (1991) had removed the remaining shreds of legitimacy draped around the argument that the producer of a database was entitled to the protections of copyright law on the basis of the sheer "sweat of the brow" effort invested in the activity of compilation, whether or not any significantly original contribution had been made to its contents.[30]

Had they looked more closely at the prevailing business practices, the High-Level Group would have discovered that a wide variety of other appropriation devices was available and was being successfully deployed by US database businesses.[31] In the case of the so-called "full text" databases, which often consist entirely of copyrighted documents, the contents do not lose their protected status by virtue of having been incorporated into a database. Another appropriation device available under existing law is the use of copyrighted enhancements: databases frequently are sold in a package along with advanced software. Because software is copyrightable (and in some instances patentable), would-be copiers must either try to market a product that is less useful, or make their own investment in developing search tools to package with the copied contents. Furthermore, technical database firms in the US were availing themselves of a variety of "self help" protections against free-riding. Custom and semi-custom databases prepared for a small number of users provide virtually automatic protection against third parties, and, more generally, contracts between the owners of such databases and their customers which limit the latter's right to use and/or disclose the contents to third parties are enforceable as trade secrets, even where the underlying information and data cannot qualify for statutory protection.

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[30] The importance of the "sweat of the brow" argument for the legal protection of database investors has tended to be exaggerated. Both before and following the 1991 *Feist* ruling, copyright applied to the original selection, co-ordination, and arrangement of data within a database; many defendants in the US therefore have been found liable for copyright infringement since 1991. It has been claimed by industry proponents of *sui generis* legislative protection that comprehensive electronically stored databases could not meet the standard set by copyright law, and such arguments conceivably may have influenced the EC's High-Level Experts Group, members of the European Parliament, or advisers to the Council of Ministers. The comprehensive character of the compilation was said to imply that no "selection" was made by the database author; and the digital nature of the contents supposedly meant that rather than having been "arranged" by the compiler, the data were "arranged" by the user employing a search engine. But apart from cases involving a comprehensive electronically stored database consisting of telephone listing, US courts have not issued rulings that would confirm such fears. Most commercially valuable databases contain many linked fields, and the selection and arrangement of data in these is a sufficiently complex task to constitute some minimal level of creativity on the part of the author. US copyright law clearly prevents the wholesale copying of such (non-trivial) database structures, and thus affords their publishers significant protection even in the post-*Feist* era.

[31] See Maurer (1999): pp. 19-21.

Where information was distributed to larger numbers of customers, the industry availed itself of the use of "shrinkwrap" and "clickwrap" licences, search-only and password protected websites, and the frequent updating of contents, editing and enhancements of search facilities – all of which are especially valuable to researchers in rapidly changing branches of science. Besides these means, Maurer's (1999) survey of industry practice found that "a significant number of products are sold without any protection at all, sometimes for comparatively high prices." The explanation offered is that large vendors can afford to circulate catalogues that enable them to reach a small number of customers who are prepared to pay high prices for comparatively obscure titles, whereas the smaller would-be copiers cannot afford the expense of trying to bring their wares to the attention of those same purchasers. Thus, there was little if any substance to the rationale that was offered for issuing the EU Database Directive, namely, that special copyright protection was necessary to "level the playing field" so that European database creators could compete on less disadvantageous terms with their American counterparts.

> It seems evident that few if any representatives among the affected basic scientific research communities in Europe, and few among those responsible for the direction of national science policies in the member countries, were engaged in the proceedings that gave rise to the recommendations of the High-Level Experts Group. Considerable attention in such quarters was being focused at the time upon the intellectual property issues involved in the transition to electronic publishing of scientific and engineering journals.[32] But far less notice was taken – either elsewhere within the Commission or outside it – of the adverse side-effects upon scientific data access and exchanges that might result from the radical legal proposal that Mr. Bangemann's Directorate was entertaining as part of its strategy to promote the development of the database industry in Europe.[33]

The EC did not set out to directly challenge the traditional resistance to protecting information that was not copyrightable, by maintaining that there was no natural domain in which non-copyrightable material might remain. Rather, it sought to correct what it saw to be unsatisfactory disincentives for investment in electronic database production. Those arose, in its view, from the absence (no more in Europe and elsewhere, to be sure) of "unfair competition legislation" that would safeguard businesses from having their database products accessed or copied at a fraction of the costs necessary to design and produce them. The Commission's immediate aim, therefore, was to prevent "unfair extraction" of the contents of databases, subject to specifying some user's rights and safeguards of the public interest in free competition. But, in the drafting and redrafting process, the public interest safeguards came to be de-emphasized in favor of stronger protection of private investor interests.

This extension of property rights over "content should be seen as not an idiosyncratic and anomalous outcome of the closed proceedings of the European Council of Ministers that produced the Common Position draft of 10 July, 1995. It is, rather, part and parcel of a much more widespread governmental response to the challenge of funding the infrastructure of an enhanced national or regional information system. Many public databases, containing information about government agencies and facilities, civil law statutes and commercial codes, judicial rulings, governmental census and survey statistics, technical reference data and standards specifications, indeed, too many to enumerate here, make up key software elements of a modern nation's information infrastructure. But, as I have remarked previously,

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[32] The history of efforts to address these issues, and the divisions of opinion within the European science communities that emerged in regard to "fair use," have been examined recently by Burnett (1999).

[33] Remarkably, the view that such a strategy for the "information industries" would not have any seriously problematic repercussions for other parts of the European innovation system appears to have been shared by Madame Edith Cresson, who at that time had responsibility on the EC for science and technology policy.

the basic governmental response to the challenge of enhancing the communications infrastructure for the digital information age increasingly has been to derogate to the private sector greater and greater responsibilities for bearing the fixed capital costs, and then hastening to endow private parties with whatever new profit opportunities might induce them to undertake the necessary investment of resources.

What has been the consequence in the instance at hand? A rapid review of the main features of the EC's Database Directive of 1996 highlights the following problematic points:[34]

- The Directive's *sui generis* approach departs from the long established principles of intellectual property law by removing the distinction between protection of expression and protection of ideas, a distinction that is central in US copyright law and was embodied in the TRIPS agreement adopted by the WTO.

- Compilers of databases in the EU will now be able to assert ownership and demand payment for licensing the use of content, which already is in the public domain, including material that otherwise could not be copyright-protected. In complying with the Directive, member states will not be providing any specific incentives for the generation of new database content (such as scientific data and information, for example), as distinguished from new compilations. Nor can it be thought that copyrights in databases are being granted as part of a social bargain, in exchange for the public disclosure of material that hitherto was not revealed.

- A second distinction fundamental in copyright law, that between original expressive matter and pre-existing expressive matter, has been discarded by language of the Directive, because the latter fails to attach any legal significance to the difference between expressive matter that already exists in the public domain, and matter that is original and newly disclosed. Domestic laws and national courts that reaffirm this omission in effect will allow a database maker to qualify for renewal of the 15-year term of exclusive rights over the database as a whole – by virtue of having made a "significant investment" in updates, additions, revisions.[35]

- Strict limitations upon re-use of database contents are imposed by the Directive, requiring third party regeneration or payment for licenses to extract such material. This would inhibit integration and recombination of existing scientific database contents with new material to provide more useful, specialized research resources.

- But regardless of whether or not it is possible in theory to regenerate the raw contents of a database from publicly available sources, under the terms of the Directive, investors in database production can always deny third parties the right

[34] The following draws upon the documented legal analysis in National Research Council (1997), pp. 148-153.

[35] See EC Directive on Databases, note 52, articles 7(1), providing an initial 15-year term from the date of completion; 7(2) extending protection for an additional 15 years if the database "is made available to the public in whatever manner" before the initial term expires; 7(3) allowing 15-year renewals for "[a]ny substantial change, evaluated qualitatively or quantitatively, to the contents of a database…from the accumulation of successive additions, deletions or alterations, which …result in …a substantial new investment." Under U.S copyright only the additions and revisions themselves – which would be considered as "derivative work" from the prior original expressive matter – would be entitled to fresh legal protection.

to use pre-existing data in value-added applications, even when the third parties are willing to pay royalties on licenses for such use. It would therefore be possible for an initial database producer simply to block subsequent creation of new, special-purpose databases which reproduced parts of existing compilations, wherever the regeneration of such data *de novo* was infeasible or terribly costly (as in the case of years of remote-sensing satellite observations, or data-tracks from high energy particle collision detectors, or multi-year bibliographic compilations of scientific publications and citations thereto).

- Where a database maker also held the exclusive rights to license previously copyright-protected publications, it would be entirely proper under the terms of the Directive to refuse third parties licenses in that material, while incorporating it within a database protected under the terms of the EC Directive. There are no compulsory licensing provisions under the Berne Convention on copyrights, and these are likewise excluded under the TRIPS Agreement. By following suit and excluding conditions for compulsory licensing, as well as omitting to provide remedies for abuse of the legal protections newly accorded to database investors, the Directive opens the door for the construction of indefinitely renewable monopolies in both non-re-generatable and non-re-generatable scientific data.

- The Directive abandons the principle of "fair use" for research, as distinct from extraction and use of data for purposes of "illustration in teaching or research." How "illustrative use" is to be interpreted remains ill defined, pending some infringement litigation that would provide opportunity for a court ruling in the matter. But the current consensus among IPR scholars is that "illustration" falls far short of the normal scope of research use of copyrighted material. Such an interpretation is consistent with the fact that

The absence of fair use exclusions for research (and research training) creates the prospect of a two-way squeeze on public sector funded research programs, as the costs of obtaining commercially supplied data are likely to rise. The 10-fold rise in the unit prices of remote-sensing satellite images that immediately followed the privatization of LANSAT satellite operations in 1985, and its withering effects upon university-based research projects, might well be recalled in this connection.[36] Continuing pressures for cuts in government budgets, taken in combination with the priority that tends to be accorded to near-term applications-oriented research vis-à-vis exploratory science, is likely to encourage derogation to commercial database generators of the function of compiling, updating and publishing databases that were created by, and remain of continuing relevance for basic public sector research. There is a two-fold risk in this situation: one is the threat to data quality in the separating of the database creation and maintenance from the scientific expertise of the research community that creates and uses the data; the other is the resulting squeeze on public research resources, as already restrictive appropriations would have to be spent on purchasing data and database licenses.

I should not leave this discussion without emphasizing that these threats to the vitality of public sector science and especially to university-based research have not been confined to the European policy scene. Indeed, they soon manifested themselves in the US, and, seen from the vantage-point developed here, the legislation introduced in the House of

[36] See the discussion in section 4, above.

Representatives in 1996 was still more radical and pernicious in its proposal of a new regime of protection for hitherto non-copyright-able data. It was in large measure reactive to the European Directive, which includes reciprocity provisions to which the US Administration was eager to respond, but it soon attracted industrial backing, including that from commercial publishers. The Administration proposal that went to the Congress and was introduced as H.R. 3125 thus followed the EU Directive's weak language regarding exclusions for "fair use." Similarly, it carried provisions for retaliatory government policies of imposing charges for publicly generated database material upon foreign users, particularly where foreign governments imposed copyright protection on data they were producing.

These innovations were tantamount to the outright abandonment of long-established features of both European and Anglo-American copyright law. Collections of data, including the relatively unstructured or unprocessed collections of primary interest to scientists have never fitted comfortably within either of those IPR regimes. Behind this traditional resistance to making them "protected property" lies the concern that facts and ideas constitute building blocks of intellectual discourse, and consequently should not be removed from the public domain. Nor is there a sound economic rationale for seeking to have them priced and exchanged through the market in the manner of other, physical inputs that are used in the conduct of scientific investigations. Unlike ordinary commodities that may be used to make other commodities, ideas and data are not exhausted by their use in the generation of still other ideas, as has already been noted.

Therefore, it is difficult to accept the logic of the position taken in 1997 by Laura Tyson in her support of the Administration-inspired database copyright protection bill (H.R. 3125). The former Chairman of the Council of Economic Advisors, in a privately commissioned report by Heller and Tyson (1999), argued that it would be economically inefficient to introduce a subsidy for academic research use at the expense of commercial database vendors – and suggested that such would be the effect of inserting adequate "fair use" exceptions into the bill. Instead, Heller and Tyson proposed that the problems that database copyright protection might create for university-based scientists should be addressed directly, by having the government expand research grant budgets enough to enable publicly funded investigators to pay the charges required by providers of these research inputs, in the same way that they had to pay for equipment, materials and laboratory facilities, and research assistants.

But, the gambit of basing such arguments on the alleged inefficiency of preferentially pricing access to information goods that are used for research purposes must fail utterly in this context. This is so because what is being proposed by the legislation is not the pricing of ordinary commodity inputs, nor even pricing of information at the extremely low marginal cost of distributing copies of the database. Rather, the claim is that since information is costly to assemble in database form, business firms should be allowed to recoup those (fixed) development costs by charging whatever they wish. It should then be seen that the subsidy in this picture is the one that is being offered in the form of legal rights to the exclusive ownership of database contents, including ownership rights over material that otherwise would have remained in the public domain. On what grounds should the government create legal protection for a private monopoly that may be exercised over a public good that may be used to produce still other public goods of the same kind, thereby raising the costs of providing something that the market systematically tends to under-supply?

Happily, in the US the first and second rounds of legislative effort failed to insert any of these novel and dubious contrivances into the fabric of intellectual property law. It is difficult to say precisely how great a role in the initial mobilization of opposition (against H.R. 3153) should be attributed to the fact that on the Western side of the Atlantic Ocean the leading scientific journals are published by non-profit scientific organizations, such as the American Astronomical Society, the American Physical Society, and the American Chemical Society, and by state and private university presses. Their voices were prominent in the counter-lobbying that was swiftly organized against the *sui generis* protections proposed for

database producers. The contrast between that and the situation prevailing in Europe is quite striking: there the business of publishing scientific journals is in the hands of an oligopoly.

Nevertheless, the representatives of the academies and professional scientific societies were not left to stand alone. A significant source of opposition to the features that closely mimicked those of the EC Directive emerged also from some producers of directories and kindred database products, as well as firms whose information services relied upon the construction of massive amounts of data gathered from the public domain.[37] Having created profitable businesses without relying on protections for their products, these firms voiced the concern that they soon might find themselves facing monopolists in the markets for their essential informational inputs, or in a race with new entrants seeking to secure exclusive rights to use the uncopyrighted materials that were embedded among the contents of their own database products.

One further remark may be added on the contrasting situations in Europe and America, regarding the political resistance of their respective academic research to these legislative encroachments upon the "knowledge commons." With the exception of the European Science Foundation, and a small number of rather new organizations, such as *Academia Europa*, professional scientific societies have remained fragmented along national lines within the European Union; since academic research funding is drawn overwhelmingly from national ministries rather than from the EU's Programmes, neither the respective national scientific bodies nor those in government positions responsible for science policy devote close monitoring and lobbying efforts to the progress of new Directive being drafted in Brussels and Luxembourg, or to the proceedings of the European Parliament in Strasbourg. By contrast, the long history of federal government funding for academic research has served to fix the attention of all who are concerned with matters touching science and science policy upon Washington, D.C., even though the research funding flows through the nation's private and state-supported universities. Undoubtedly this has contributed to the closer integration and greater political sophistication, which the American scientific establishment displays in mobilizing co-ordinated lobbying campaigns on issues of professional concern.

One thus may understand why in Europe the research community's capacity remains comparatively weak, when it comes to mounting any very significant resistance to the unbalancing effects of ill-conceived industrial policy initiatives upon the region's science and technology-based system of innovation. Yet, it would be far from safe to expect that lacking the vision and support of enlightened governmental leaders, either of these regions' research communities will be capable of defending the Republic of Open Science against future pressures to privatize the knowledge commons. Where, then, does that leave the prospects for the growth of scientific and technological research capabilities among the developing countries?

7. What Is To Be Done? Protecting Open Science Research in the Digital Age

When considering the available courses of action to counter threats to the pursuit of knowledge arising from recent innovations intended to strengthen intellectual property protections, distinctions of two kinds help to simplify the discussion, although not the

[37] See, e.g., US Congress, House Hearings (1999), for material submitted by the Association of Directory Publishers (pp.88-90), supporting the more limited forms of protection offered under H.R.1858; and testimony of Matthew Rightmire, Director of Business Development, Yahoo! Inc.(pp.30-34).

problems that need to be addressed. Firstly, there is an obvious difference between the altered terms and scope of statutory intellectual property protections, on the one hand, and on the other hand, legislative steps designed to reinforce the use of technologies of "self help" that enable copyright owners to more perfectly control the dissemination of digital content (whether that is legally protected or not). A second distinction has to be drawn between the situation of countries where legislative innovations affecting intellectual property may be under consideration, and those cases in which such statutes already are *faits acomplis* -- so that the questions of practical interest concern implementation and enforcement.

For most of the nations of the world, the appropriate recommendations in regard to both the technological and the legal measures that would restrict access to digital data used for research and training would seem to follow Nancy Reagan's admonition to youths who are offered the opportunity to experiment with addictive drugs: "Just say 'No'!" It is relevant that this option remains one that is open to all the countries, developed and developing alike, that are signatories to the TRIPS Agreement, and, of course to those who have not yet joined the WTO. To date, at least, there is no international convention in force for the legal protection of databases and the articles of the TRIPS Agreement do not pertain to database protection *per se*. Thus, unless a case were successfully to be made for interpreting the *sui generis* protections for databases created by the EC Directive of March 11, 1996 as somehow being covered under copyright, nothing in the TRIPS agreements would oblige other nations to follow the (misdirected) leaders in this particular regard. Such an interpretation, moreover, would be utterly tendentious in view of the numerous respects in which the terms of the EC Database Directive has been seen to deviate from the principles embraced by national and international copyright law.

Much the same general position may be advanced in regard to the possible products of the legislative drive to provide legal reinforcement for technological measures of "self help" on the part of copyright owners. As has been noted (in section 4, above), the US Digital Millennium Copyright Act (1998) includes language making it illegal to furnish -- whether by importation or manufacture, and whether by sale or free distribution -- all means of circumventing "any technological measure that effectively controls access" to a copyrighted work. As dubious, and in some respects as counter-productive as these sections of the DMCA have been found to be, by both legal and technical experts,[38] it remains quite conceivable that an effort will be made to press other countries into following suit. In an immediate sense, however the issue in this case is not one of legal principle, but instead belongs to the wider and unresolved debate about the feasibility and desirability of uniform international standards of *enforcement* of intellectual property rights.

Nothing presently compels countries that are signatory to the TRIPS Agreement to arrive at uniformity in the degree of enforcement of their intellectual property laws. It is true that the international conventions and laws governing patents, trademarks, copyrights, trade secrets, industrial designs, semiconductor mask works, and still other protections, all must be "effectively implemented and enforced" by each of the nations belonging to the WTO.

[38] On the question of "counter-productive" effects, Dam (1998) notes the testimony by cryptography experts to the effect that the wording of the 1998 DMCA (US Code, 17, §1201) would make it illegal even to devise and distribute algorithms used in testing encryption systems by trying to defeat them; more generally, it would greatly impede research aimed at making such devices cheap and faster to apply. This point nicely recapitulates the larger theme, viz., that would-be protectors of technological innovation too frequently fail to grasp that information is an input in the process of generating new knowledge that will form the basis for further innovation.

Nevertheless, the term "effectively" remains subject to considerable variations in interpretation.[39] In addition, the Agreement explicitly recognizes several bases for exemptions from the provisions made for protection of the rights of owners of intellectual property, including appeal to "fair use" or "public interest" (Articles 13, 17,24,27:2, 30 and 37). It may be argued, therefore, that inasmuch as national governments under the Agreement retain the right to create a haven for "fair use" of protected intellectual property in the public interest, their ability to effectively exercise that right would be impeded by requiring that they prevent their own nationals from circumventing unilaterally imposed access blocking technologies in order to avail themselves of those "fair use" exemptions for those very same scientific research and training purposes.

The preceding remarks obviously apply to the situation in which the developing economies find themselves with respect to intellectual property protections that would have seriously inhibited worthy, "public interest" activities, had not the latter gained statutory exemptions under the laws' provisos for "fair use." It remains an interesting question as to whether it sphere of applicability extends still farther: could it also encompass retroactive remedial legislative actions on the part of the economically advanced member states of the EU that have not yet implemented the EC Directive on the Legal Protection of Databases in their national laws? Whereas some countries, such as the United Kingdom, were quick to implement the Directive without entering any exceptions or liberalizing interpretations, other European states, such as the Netherlands as well as Greece, Ireland, Italy, Portugal, and Spain, have not rushed to comply with its terms. This has opened a window for attempts to modify the Directive's force by suitable interpretations in the way it is implemented. But, rather than leaving it to individual members to undertake to ameliorate the harm that a literal acceptance and enforcement of the text of the Directive might do to the scientific research community in Europe, it would be far more satisfactory for the EC to now propose a "harmonized" set of fair use exemptions, as a minimal remedial step.

That solution, however, is not likely to emerge spontaneously, not even in the wake of the departure of EC Commissioner Bangemann and the scandal-prompted reforms undertaken by the new leadership of EC President Romano Prodi; some very considerable amount of political pressure would have to be brought to bear upon the Commission, and a coalition formed among the smaller member states who have yet to implement the Directive would seem to be among the few plausible ways in which such pressure could materialize. Yet, in view of the politically fragmented condition of Europe's basic science research communities, the prospects of an effective coalition emerging would remain rather remote unless it were to be energized by business corporations similar to those in the US who have lobbied actively against counterpart database legislation. The political economy of the question, therefore is likely to turn not upon the longer-run implications for science and technology in Europe as the logic of economic analysis might dictate, but instead upon whether or not there exists a significant section of European industry that comes to perceive a direct and immediate source of harm to their economic fortunes, in the extraordinary nature of the protections allowed by the EC's Database Directive.

According to the American writer and wit, Mark Twain, "the man who would rid the world of a cancer is not obliged to put something in its place." Nevertheless, the reality of the situation is that in the wake of the EC initiative to legally protect databases, regardless of whether or not there was empirical evidence to suggest that such measures were required for

[39] See Reichman (1998) on the interpretation of the enforcement articles included in Part III of the TRIPS Agreement, and the survey of implementation issues in Keely (2000).

the growth of the database industry in Europe, this particular protection genie has got out of the bottle and won't be stuffed back into it completely. What this means is that remediation cannot simply take the form of a return to the *status quo ante*. As some alternative recommendations for intellectual property protection in the market for scientific databases are in order, I should not conclude the discussion without considering these, however briefly.

In the view of most economists, the "first best" allocation system in situations where goods are produced with high fixed costs but far lower marginal costs, is to apply what is known as the "Ramsey pricing" rule. This fits the case of information products such as scientific publication and data, where the first-copy costs are very great in relationship to the negligible unit costs of copies. Ramsey pricing in essence amounts to price discrimination between users whose demands are inelastic and those users for whom the quantity purchased is extremely price-sensitive. The former class of buyers therefore will bear high prices without curtailing the quantity purchased of the goods in question, and hence not suffer great reductions in consumption utility on that account, whereas the low prices offered to those in the second category will spare them the burden of economic welfare reducing cutbacks in their use of the good.

The case might then be made for treating scholars and public sector, university-based researchers as having highly elastic information and data demands. Such a characterization would follow from considering that this category of knowledge-workers is employed on projects that have fixed budget allocations from public (or non-profit) entities, organizations that are expected to promote the interests of society at large. Since there is strong complementarity between their data and information requirements, on the one hand, and on the other resources they use in their research, the effects of raising the real price of this input are tantamount to sharply reducing the quantity of useful work that such projects can accomplish so long as their budgets remain fixed. Obviously, there is no workable economic or political mechanism that would serve to "index" the nominal value of public research budgets on the prices of commercially provided data. Even were such mechanisms to be found, commitment to implement them on the part of the rich societies would most likely result in pricing the use of scientific information and data beyond the reach of many poorer societies. The general conclusion of this line of reasoning is simple: statutes that would establish legal ownership rights for compilers of scientific and technological databases also should include provisions mandating compulsory licensing of scientific database contents at marginal costs (of data extraction and distribution) to accredited individuals and research institutions.

Of course, a second-best version of such a policy would be to grant researchers (and educators) broad "fair use" exemptions from the legal enforcement of database owner's rights, dispensing with recovery of marginal costs except where special, value-adding facilities were used to extract the contents from protected databases. One reason against dispensing entirely with marginal cost charges is that it may well be the case that marginal extraction and copying costs might be lower for the database owner than for the research user, but, in the absence of quoted prices for the service, research groups may not be aware of this and so waste time and resources in performing tasks that could be more efficiently undertaken by the commercial database firm. In other words, allowing users to "do it for themselves" could deny both parties the benefits of the economies of scale and scope as were available. On the other side of the argument, it would be desirable to limit the incentives for database producers to bundle unwanted and costly extraction and reproduction services with

the contents of their database, including services whose costs cannot be readily established and which give rise to opportunities for cross-subsidization among different classes of users.

Compulsory licensing has further attractions as a remedy in this context. No protections are provided in the 1996 Database Directive against the abusive exploitation of market power arising in cases of sole supply of data; or where high set-up costs tend to preclude competitive entry into niche markets already occupied by early commercial database generators. The obvious remedy here would be to stipulate conditions (derived in accord with the principles underlying existing competition laws) that would trigger the "regulatory" imposition of compulsory licensing of database contents at the marginal costs of data provision. Such provisions would not be inconsistent with the TRIPS Agreement, Part II of which (under Article 40) sets out conditions under which anti-competitive licensing practices that are shown to prevent dissemination of a technology may be restricted.[40]

But the foregoing modest proposals are just the beginning of what must become a more intense discussion, involving participants drawn from many disciplines in the sciences, legal scholars and business lawyers, representatives of the affected industries and policy-makers from the developed and developing countries alike. There is much to do to protect the vitality of the global science system of open collaboration, and the time to do it has become short.

[40] See Keely (2000), pp.6-7.

Table 1

Performance of US Database Industry
after the 1991 Decision in *Feist v. Rural Telephone*

Performance indicators	1991	1997	% change
Number of databases	7,637	10,338	35%
Number of files within databases (billions)	4.0	11.2	180%
Number of online searches (millions)	44.4	(88.1)	98%
Private sector's share in number of databases*	0.70	0.78	

Note: * The private sector's share in 1977 was 0.22.

Source: http://www.databasedata.org/hr1858/legalprt/hegalprt.html.

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â€¢ While technical protection for intellectual property is often construed as protecting the rights of rights holders to collect revenue, this viewpoint is too narrow. Technical protection offers additional important services, including verifying the authenticity of information (i.e., indicating whether it comes from the source claimed and whether it has been alteredâ€”either inadvertently or fraudulently).Â encrypted, even the public key used to encrypt it cannot be used to decrypt it. The idea is to keep one of these keys private and publish the other one; private keys are kept private by individuals, while public keys are published, perhaps in an online directory, so that anyone can find them. If you want to send a secret message, you encrypt the message with the recipient's public key. Global Science, Intellectual Property and the Digital Technology Boomerang, SIEPR Discussion Paper No. 00â€“02, Stanford, CA: Stanford Institute for Economic Policy Research [http://129.3.20.41/eps/dev/papers/0502/0502010.pdf, accessed 27 April 2011]. Davies, Simon (2003), â€˜The Proposed Software Directive: A Userâ€™s Commentsâ€™, Journal of Information, Law & Technology 3(1). Davis, Lee (2004), â€˜Intellectual Property Rights, Strategy and Policyâ€™, Economics of Innovation and New Technology 13(5): 399â€“415. Deere, Carolyn (2009), The Implementation Game: The TRIPS Agreement and the Global Politics of Intellectual Property Reform in Developing Countries, Oxford and New York: Oxford University Press. della Porta, Donatella, and Mario Diani (2006), Social Movements. Public funding and the creation of a knowledge commons. Digital & Data. Duncan McCann. 29.7.2020.Â However, any intellectual property that results from publicly funded research does not belong to the public, who paid for it, but instead is available for the private sector to enclose and profit from. Indeed, the state does not recoup anything directly for that investment.Â It clearly acknowledges the nature and significance of the investment of public money into R&D and ensures that any resulting IP is owned collectively.Â The diagram below, taken from the same book, shows some of these technologies alongside the US public sector bodies that developed them. Global Science, Intellectual Property and the Digital Technology Boomerang. Dept. of Economics, Stanford University, working paper 00â€“16, 2000.Google Scholar. David P.A. Digital Technologies, Research Collaborations and the Extension of Protection for Intellectual Property in Science: Will Building â€˜Good Fencesâ€™ Really Make â€˜Good Neighborsâ€™?, in IPR Aspects of Internet Collaborations, Final Report, Eur 19456, European Commission, 2001.Google Scholar.Â Rose C. The Comedy of the Commons: Custom, Commerce and Inherently Public Property. University of Chicago Law Review 1986; 53: 3.CrossRefGoogle Scholar. Schankerman M. and Scotchmer S. Damages and Injunctions in the Protection of Proprietary Research Tools.